

# **Application of generative adversarial networks (GAN) for ophthalmology image domains: a survey**

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## **Abstract**

**Background** Recent advances in deep learning techniques have led to improved diagnostic abilities in ophthalmology. A generative adversarial network (GAN), which consists of two competing types of deep neural networks, including a generator and a discriminator, has demonstrated remarkable performance in image synthesis and image-to-image translation. The adoption of GAN for medical imaging is increasing for image generation and translation, but it is not familiar to researchers in the field of ophthalmology. In this work, we present a literature review on the application of GAN in ophthalmology image domains to discuss important contributions and to identify potential future research directions.

**Methods** We performed a survey on studies using GAN published before June 2021 only, and we introduced various applications of GAN in ophthalmology image domains. The search identified 48 peer-reviewed papers in the final review. The type of GAN used in the analysis, task, imaging domain, and the outcome were collected to verify the usefulness of the GAN.

**Results** In ophthalmology image domains, GAN can perform segmentation, data augmentation, denoising, domain transfer, super-resolution, post-intervention prediction, and feature extraction. GAN techniques have established an extension of datasets and modalities in ophthalmology. GAN has several limitations, such as mode collapse, spatial deformities, unintended changes, and the generation of high-frequency noises and artifacts of checkerboard patterns.

**Conclusions** The use of GAN has benefited the various tasks in ophthalmology image domains. Based on our observations, the adoption of GAN in ophthalmology is still in a very early stage of clinical validation compared with deep learning classification techniques because several problems need to be overcome for practical use. However, the proper selection of the GAN technique and statistical modeling of ocular imaging will greatly improve the performance of each image analysis. Finally, this survey would enable researchers to access the appropriate GAN technique to maximize the potential of ophthalmology datasets for deep learning research.